ORGANISATION AND CONTROL OF THE PS LOW LEVEL RF IN 1998

R. Garoby

1. Introduction

Extensive modifications are planned during the shut-down 97-98 to prepare the PS injectors' complex for the delivery of the LHC types of beams [1]. Consequently all modes of operation of the PS RF will completely change. For example, harmonics 8 and 16 will be used for almost all beams, while harmonics 20 and 6 will disappear. Because of these major changes, the PS Low Level RF has to be completely re-designed. Consequences include the simplification of the lay-outs, the standardisation of new electronics modules and the replacement of old racks and their auxiliary equipment (timing distribution, ventilation etc.).

According to the draft PS Complex Schedule for 1998 (see Annex 1 derived from [2]), the planned modes of operation are given in section 2.1, and section 2.2 lists the beam controls to be implemented in order of priority. The organisation of the low level RF is described in section 3. Operation of these systems is illustrated in Annexes 2, 3 and 4 where the required sequence of events ("timings") during a machine cycle is given, together with the actions on the hardware.

2. Future operating modes in the PS

The purpose of this section is to list in order of priority the different types of beams required until the end of 1999 from the PS complex. As soon as a new type of beam will be made available, numerous uses will be satisfied, with different adjustments of the control parameters.

2.1. Planning of beams

The first types of beams to be delivered correspond to existing beams for physics. The leptons beams are unchanged, but the proton ones are prepared differently from today because of the new harmonic numbers [1]. That is summarised in Table 1.

USER	**CHARACTERISTICS**		
	Harmonic(s)	**Beam intensity**	**Peculiarities**
SFT (Protons)	8 -> 16 -> 420	~ 3 10^{13} ppp	• Splitting h=8->16 • Deb. / reb. h=420 @ 14 GeV
PHYSE	8	< 4 10^{11} ppp	• Deb. @ high energy
SPP / SPN (using C114)	8 & 240	2 10^{11} ppp	• Double batch synchro. and ejection

Table 1: First priority operations (March 98)

Tests in view of the proton beam for LHC will begin in the summer of 1998, as well as the delivery of a probe beam for investigation of single bunch stability in SPS (Table 2).

USER	CHARACTERISTICS		
	Harmonic(s)	**Beam intensity**	**Peculiarities**
LHC (Protons)	8 -> 16 -> 84 & 168	~ 10^{13} ppp	• Double batch injection of 2 x 4 bunches from the PSB • Splitting h=8->16 • Deb. / reb. h=84 @ 26 GeV • Bunch rotation with h=84 and h=168 before ejection
SPSMD	8 -> 16 (84)	< 2 10^{11} ppp	• Single bunch with variable length and Δp on h=16 • Single bunch transferred from h=16 to h=84 • Bunch compression with h=84 and h=168

Table 2: Second priority operations (~ July 1998)

The setting-up of Lead ions acceleration on h=16 must take place before September, when fixed target physics with Lead ions resumes. Autumn 1998 is also the time when the AD starts, so the single bunch test beam at 3.5 GeV/c (TSTAD) has to be ready first, followed by a simple pbar production beam for the first attempts with anti-protons at the end of the year. Table 3 illustrates these requests.

USER	CHARACTERISTICS		
	Harmonic(s)	**Beam intensity**	**Peculiarities**
SFT (Lead)	16	~ 4 10^{9} cpp	
TSTAD	8	< 10^{11} ppp	Single bunch. Synchro. + ejection @ 3.5 GeV/c
AD	10	> 5 10^{12} ppp	• 2 PSB rings injected into 2 successive buckets at h_{PS}=10 • Synchro. + bunch rotation before ejection

Table 3: Third priority operations (~ September 1998)

Machine experiments to prepare the full scale pbar production beam will start in the 4th quarter of 1998, when the hardware required will begin to be available. Given enough efforts and machine time, that beam is planned to be ready for operational use at the end of 1999. Leptons acceleration with the 80 MHz system (h=168) can also be tested during that year. (Table 4)

USER	CHARACTERISTICS		
	Harmonic(s)	**Beam intensity**	**Peculiarities**
AD	8, 10, ... 20	> 10^{13} ppp	• 4 PSB rings injected into 4 successive buckets at h_{PS}=8 • Batch compression at 26 GeV (h from 8 to 20) • Bunch rotation before ejection • Synchronisation
SPP / SPN (using C80)	8 & 168	2 10^{11} ppp	Will permit removal of C114 from the PS

Table 4: Fourth priority operations (1999)

2.2. Beam controls hardware

The beam controls and their planning of availability (Table 5) result from the requirements given in section 2.1.

BEAM CONTROL	SPECIFICATIONS			
	Deadline (physics)	USERS	Range	Capabilities
h8+16 protons	**03/98**	SFT (Protons) PHYSE TSTAD	4 10^{10} -> 4 10^{13} ppp	• Splitting h=8->16 • Acceleration on h=8 or h=16 • Hereward damping • Bunch rotation • Double batch injection • Synchro. h=1
200 MHz	**03/98**	Proton beams SFT(Protons)	~ 3 10^{13} ppp	• Controlled longitudinal blow-up • Rebunching on h=420 @ 14 GeV
h8+240 leptons	**03/98**	SPP/SPN	10^{9} -> 2 10^{11} ppp	• Double batch synchro. at ejection
h84+168 protons	**07/98**	LHC (Protons) SPSMD Test beam for LHC exp.	10^{11} -> 2 10^{13} ppp	• Bunch rotation • Phase stabilisation
h16 ions	**09/98**	SFT (Lead)	10^{9} -> 10^{12} cpp	•
h10 protons	**09/98**	AD	10^{11} -> 10^{13} ppp	• Synchro. h=10 • Bunch rotation
h8+168 leptons	**03/99**	SPP/SPN	10^{9} -> 2 10^{11} ppp	• Double batch synchro. at ejection
hsweep protons	**09/99**	AD	10^{12} -> 2 10^{13} ppp	• Batch compression (h from 8 to 20) • Bunch rotation • Synchro.

Table 5: Review of beam controls

Most operations will exploit the beam controls on harmonics 8 & 16 for protons which has to be very versatile. It will replace in that role the original PS beam control on h=20.

Ions acceleration will be handled by a separate beam control operating also on h=16, and optimised for low intensity.

The pbar production beam on h=10 will be temporary, providing the capability to accelerate, synchronize and send the intensity from 2 PSB rings onto the target. It will be replaced by the full scale beam control for pbar production as soon as it is assembled and adjusted (~ end 1999).

The low level RF driving the 40 and 80 MHz cavities is classified as a beam control, although it is mostly open loop and does not encompass the kind of features usually encountered. It is of a similar nature than the low level hardware driving the 200 MHz cavities which will also be improved.

Lepton operations will stay unchanged until equipment is ready and demonstration is made of using the 80 MHz instead of the 114 MHz hardware. The choice will then be possible to switch to the new systems and remove the 114 MHz cavities from the PS ring.

3. PS low level RF after the start-up 1998

3.1. Principles

A typical beam control driving the 10 ferrite loaded cavities is shown in figure 1. It makes use of:

- ✓ standard common facilities (Radial position processing, Beam phase Pus processing, Revolution frequency programme, etc.),
- ✓ control information in the form of timings, functions of time (analogue or digital) and digital words,
- ✓ synchronisation trains from the up- and down-stream machines,

and it delivers:

- ✓ the RF signals driving the cavities amplifiers,
- ✓ synchronisation trains at the RF and revolution frequencies
- ✓ miscellaneous signals for the common facilities (Local Oscillator, etc.).

Block diagrams are given in the following sections which are meant to illustrate the fundamental skeleton of each system which will be modified during the 97-98 shut-down. They make use of standard devices in NIM modules and deliberately lack details on auxiliary functions like signal distribution.

3.2. Common facilities

To measure the phase of the RF component of the beam, the signals from the 4 phase Pick-ups are processed according to the drawing in figure 2. The signals from diametrically opposite pick-ups are added after equal electrical delays, which gives the correct phase for all event harmonics. A phase-shifter in the I.F. path for Pus 38 + 98 provides the capability to properly phase it for addition with the I.F. from the other pair of Pus.

In the case of the ferrite cavities, special summation modules are used, each one equipped with the adequate fixed phase-shifters for a given harmonic (figure 3). Decoupling between uses and cable loss compensation is guaranteed by the use of active electronics ("Cavity return monitor and detection). Moreover, one set of such modules is dedicated to observation and measurement, while the second set is used only by beam controls.

Beam radial position is obtained with the same processing than presently (figure 4). The mean position is estimated from the mean value taken from three pick-ups in sections 22, 51 and 96. That system can work on any harmonic number in his frequency range (2.7 to 10 MHz), provided the correct Local Oscillator is supplied.

The feedback system for damping coherent quadrupolar oscillations of the bunches ("Hereward Damping") is based on components presently in operation (figure 5). The module controlling the tunable filter ("Synchrotron Frequency Computer") cannot easily tackle the harmonic numbers 8 and 16. The proposal is to replace it in 1998 by a GFAS whose function will be tailored to every user of high intensity beam. The medium term aim (1999 - 2000) is to upgrade the full system with modern electronics providing all the capabilities required by the new modes of operation.

3.3 Beam Controls

The beam control on h=8 + 16 for proton (figure 6) incorporates standard facilities like the adjustment of phase at injection, and the features for crossing transition. But it is also equipped with special functions for:

- ✓ double batch injection from the PSB, with a separate control of the phase and bucket number for the second injection,
- ✓ dual harmonic operation for bunch splitting or simply change of bunching harmonic,
- ✓ synchronisation at the revolution frequency, for energy stabilisation (test beam for AD) of other gymnastics like matched transfer into an h=84 bucket (test beam for SPS).

Lead ions acceleration for fixed target physics in SPS will be handled with a simpler beam control working on h=16 and optimised for low beam intensities (figure 7). It is simply an evolution of the existing beam control for ions on h=20. Wide-band phase-shifters are introduced in the driving and return paths of the cavities to permit operation on h=16.

The full scale pbar production beam for the AD machine [3] will be similar in principle to the beam used for the AC [4]. The aim is to build it with up-to-date electronics to provide the new necessary features in much less volume and with less controls and cabling needs [5]. Hardware preparation is planned to last until the Autumn of 1998, and numerous tests with beam have to take place before the production beam can be effectively used in operation (end 1999). Since anti-protons will be processed in the AD already at the end of 1998, a temporary beam control will be installed to supply the target with 2 bunches spaced by 1 RF period on h=10. The proton beam intensity should approach 10^{13} ppp, and bunch rotation will be possible in the AD. That beam control is kept as simple as possible (figure 8) and deserves no particular comment. Its modules will become spare parts of the other system when the full scale installation will replace it.

3.4. Switching systems

A number of trains originate from the low level RF equipment to be used by many different type of users, including the RF itself. These are:

- ✓ the Local Oscillators (mostly used by the common low level RF facilities),
- ✓ the reference RF and revolution frequency for PSB synchronization,
- ✓ the RF and revolution frequency (for beam instrumentation, injection/ ejection systems, etc.)

Multi-position switches are used to select the correct sources, with a uniform convention for the system corresponding to each input channel (see table of Channel uses in figure 9, for example).

The Local Oscillator selection system (figure 9) can deliver simultaneously 2 different signals, which is necessary to measure phase simultaneously on different harmonic (of interest for the h=8 + 16 beam control for protons, and for the future beam control for pbar production).

The need for a switching system to select the trains for PSB synchronisation is new (figure 10). It results from the flexibility required in the future, when the PSB has to be able in p.p.m. to synchronise onto an RF which is not equal to the RF on the PS cavities, and to send its bunches into specified PS buckets.

The selection of the RF and revolution trains is represented on figure 11, the major change with respect to the past being the removal of obsolete possibilities and the standardisation of the definition of the input channels.

3.5. Low level RF for high frequency (> 10 MHz) systems

The 200 MHz system will still be used for rebunching on h=420 at 14 GeV, and the corresponding hardware will not be modified. But the low level RF for controlled longitudinal blow-up will be upgraded, using a fast 200 MHz phase-shifter directly driven by the serial train from the GFAS for phase modulation (figure 12). Changing the phase modulation function from a sine (present case) to a saw-tooth, the investigation of blow-up techniques providing flat-topped bunches will be easily possible.

The equipment driving the 40 MHz cavities is sketched in figure 13. There is only one sampled feedback system stabilising over the medium and long term the phase of the field in the cavity with respect to the reference derived from the SPS trains. An open loop phase-shifter is also implemented to compensate for the orbit elongation induced by the ejection bump.

The low level RF for the 80 MHz systems (figure 14) is very similar to the one at 40 MHz. It also contains a feedback loop to stabilise the phase of the field in the cavities. Compensation of the orbit elongation is automatically achieved in deriving the 80 MHz by multiplication of the phase modulated 40 MHz.

3.6. Systems operation

To illustrate how these systems work and to help define the control needs, Annexes 2, 3 and 4 list the sequence of events ("timings") required for the proper operation of the various beam controls.

ACKNOWLEDGEMENTS

Numerous ideas implemented in these descriptions came during discussions with J.L. Vallet. I also benefited from the work of A. Blas on the low level RF of the PSB and of the results of the Machine Experiments done in 1997.

REFERENCES

[1] Beams in the PS Complex during the LHC Era, R. Cappi, R. Garoby, S. Hancock, M. Martini, J.P. Riunaud, K. Schindl, H. Schönauer, CERN/PS 93-08 (DI) Revised.
[2] Draft of Schedule for the PS Complex in 1998, J. Boillot.
[3] Design Study of the Antiproton Decelerator, S. Maury (editor), CERN/PS 96-43 (AR).
[4] New RF Exercises envisaged in the CERN-PS for the Antiproton Production Beam of the ACOL Machine, R. Garoby, CERN/PS 85-36 (RF).
[5] Multi-harmonic RF Source for the Anti-Proton Production Beam of the AD, R. Garoby, PS/RF Note 97-10.

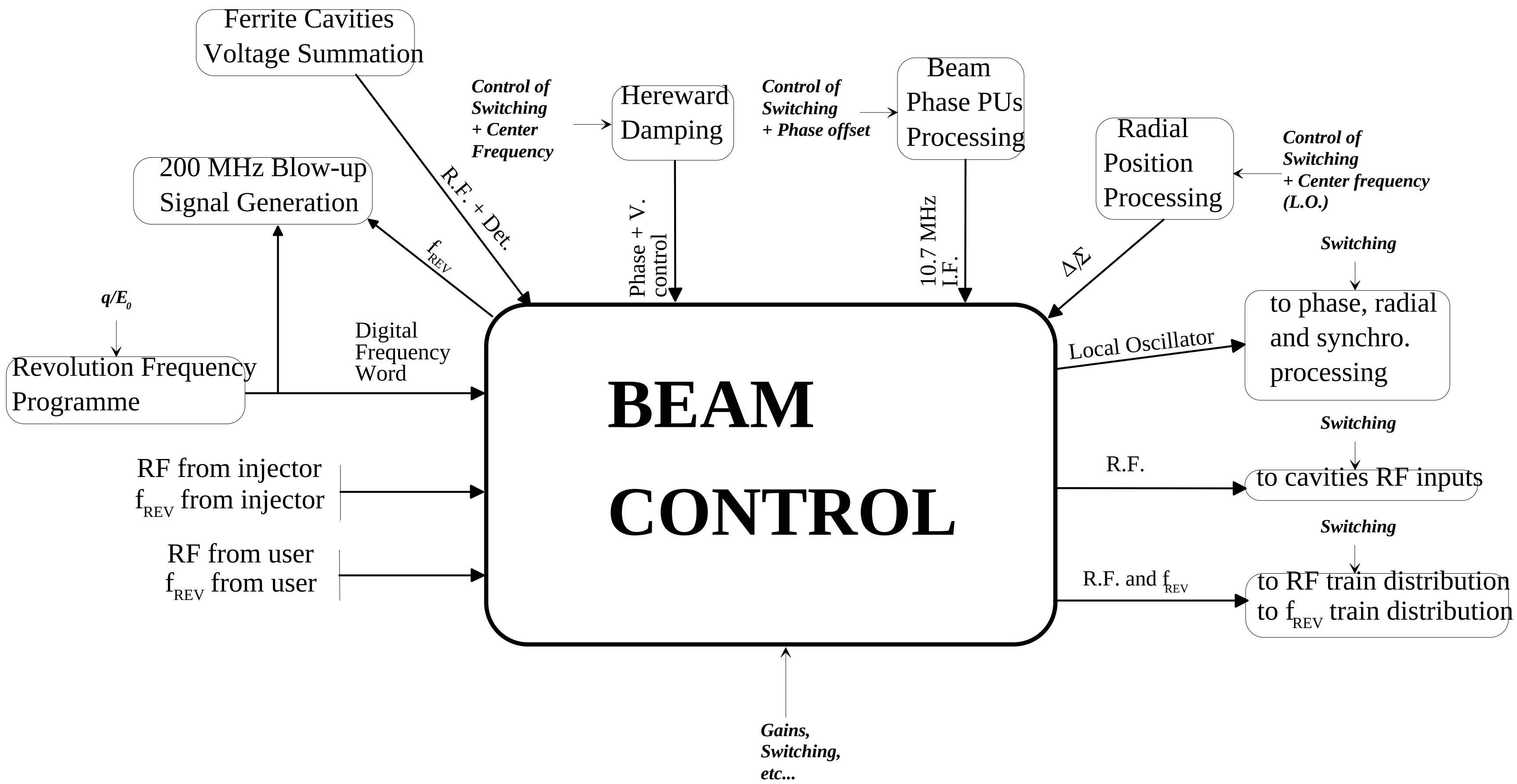


Figure 1: Typical set-up of a PS Beam Control

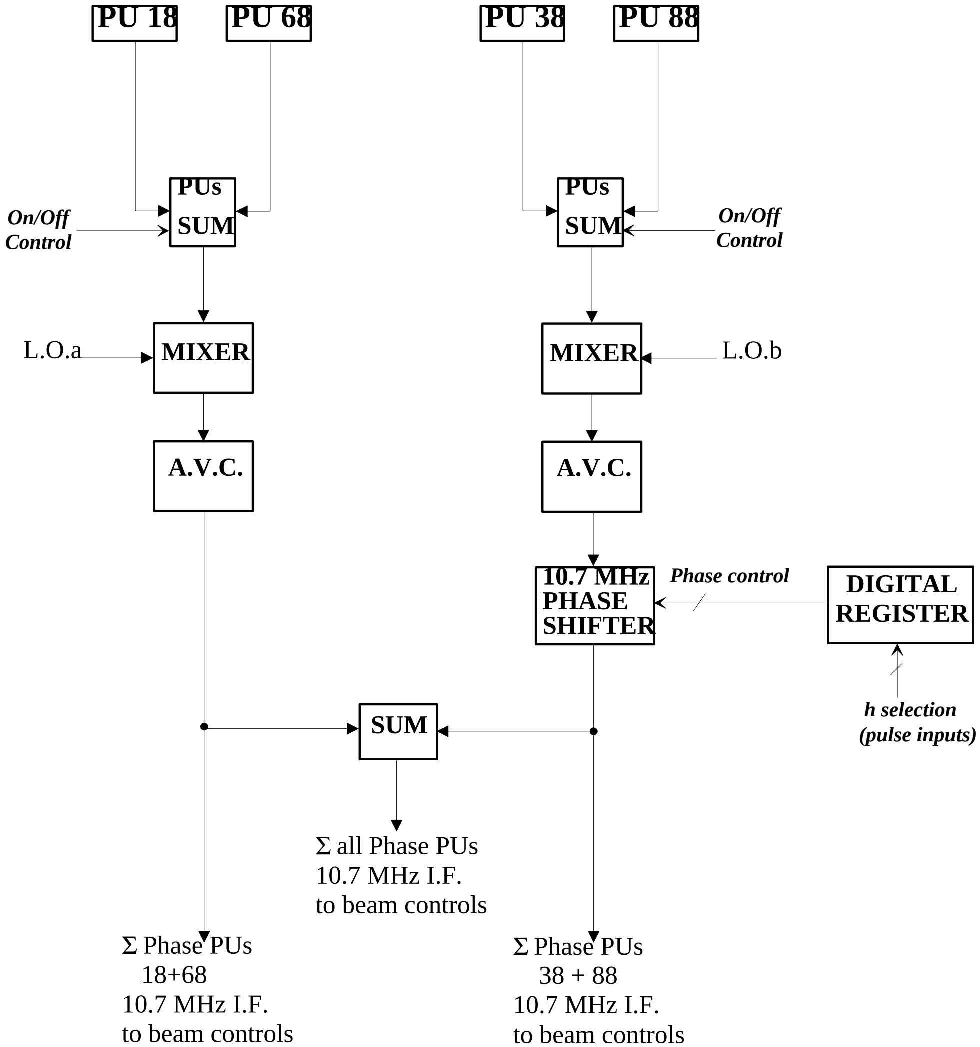


Figure 2: Processing of beam phase PUs signals

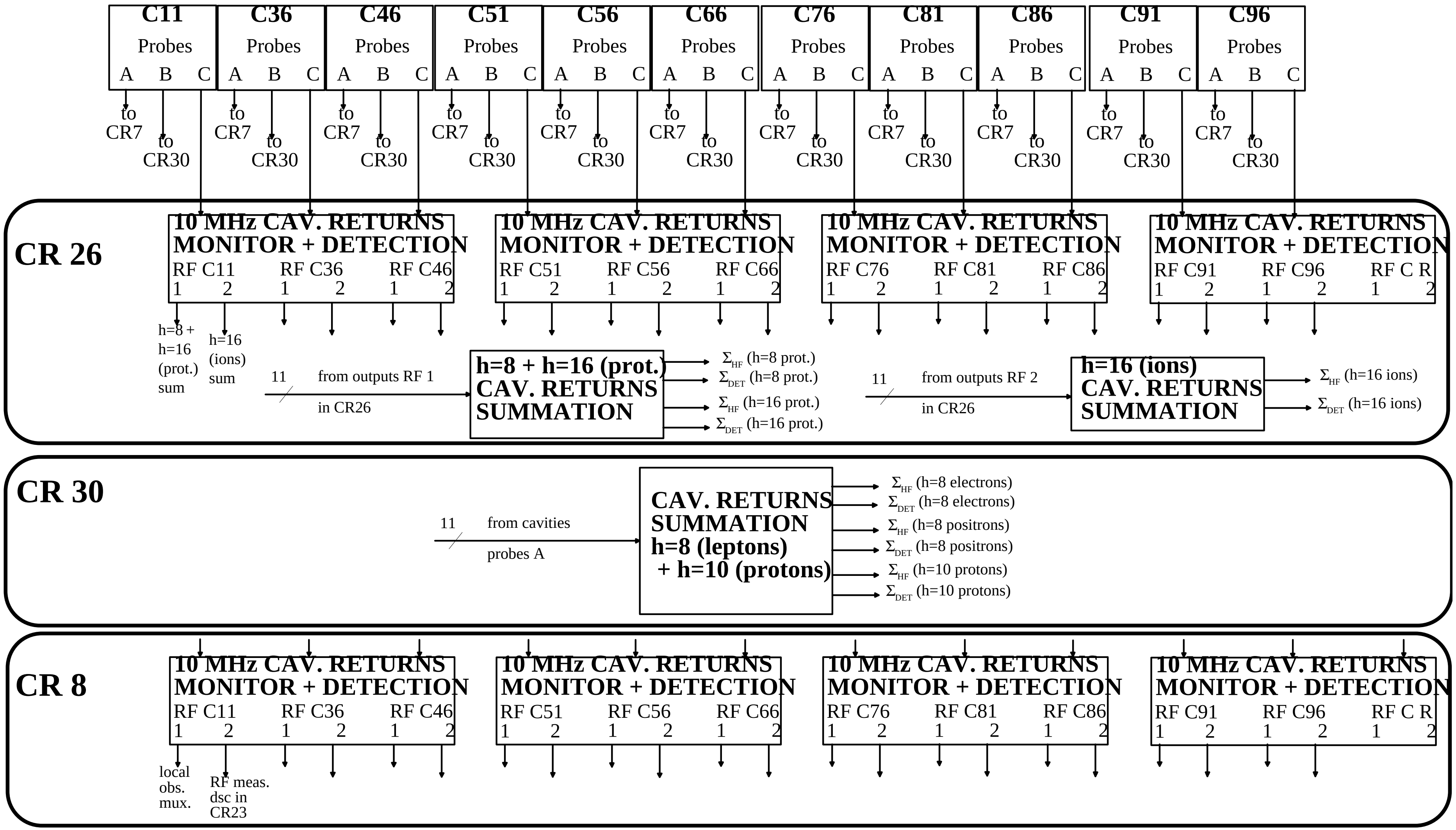


Figure 3: Summation of Ferrite cavities voltages

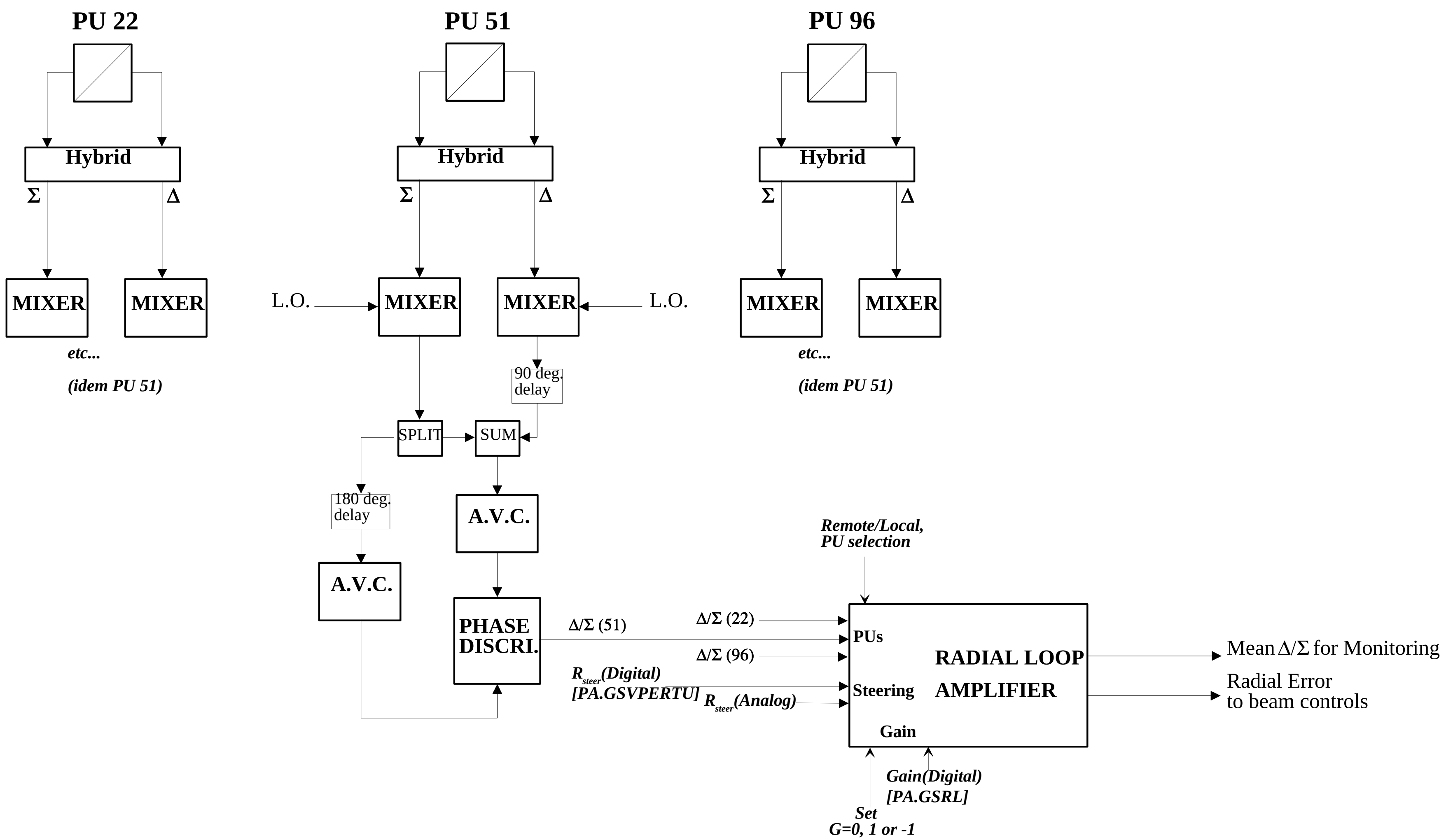


Figure 4: Processing of radial position

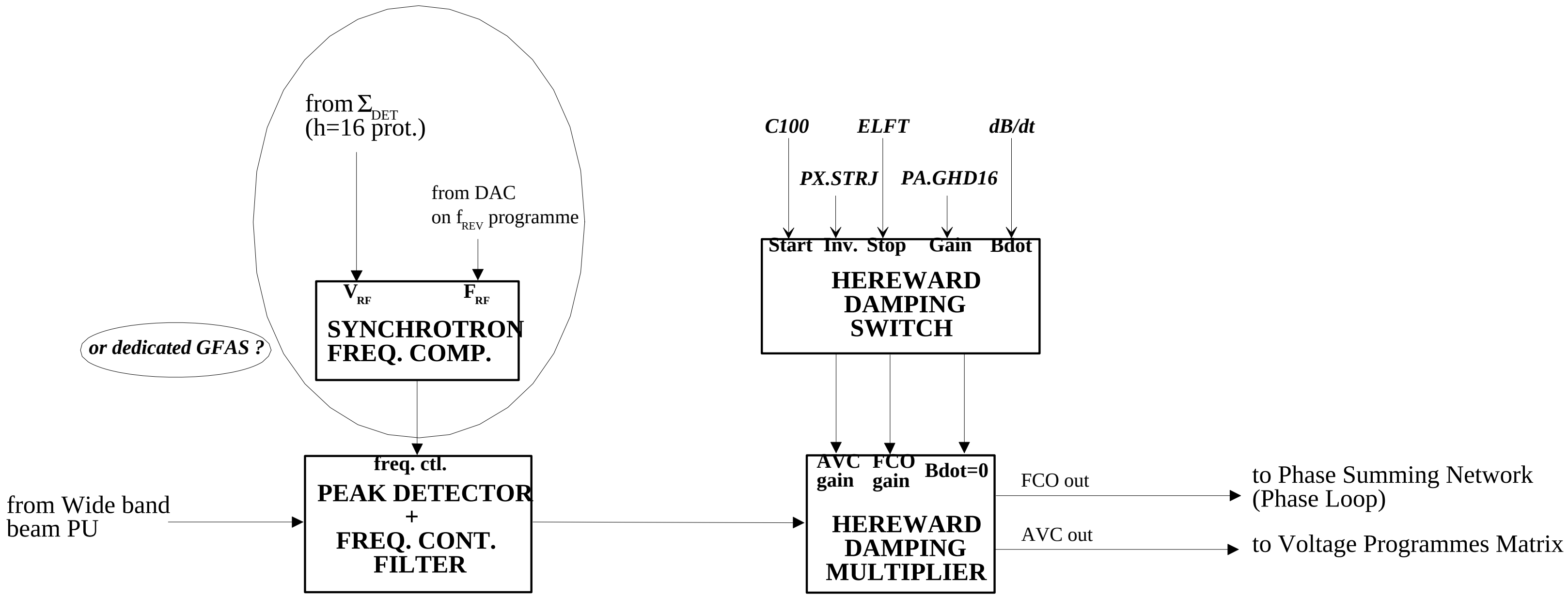


Figure 5: Hereward damping

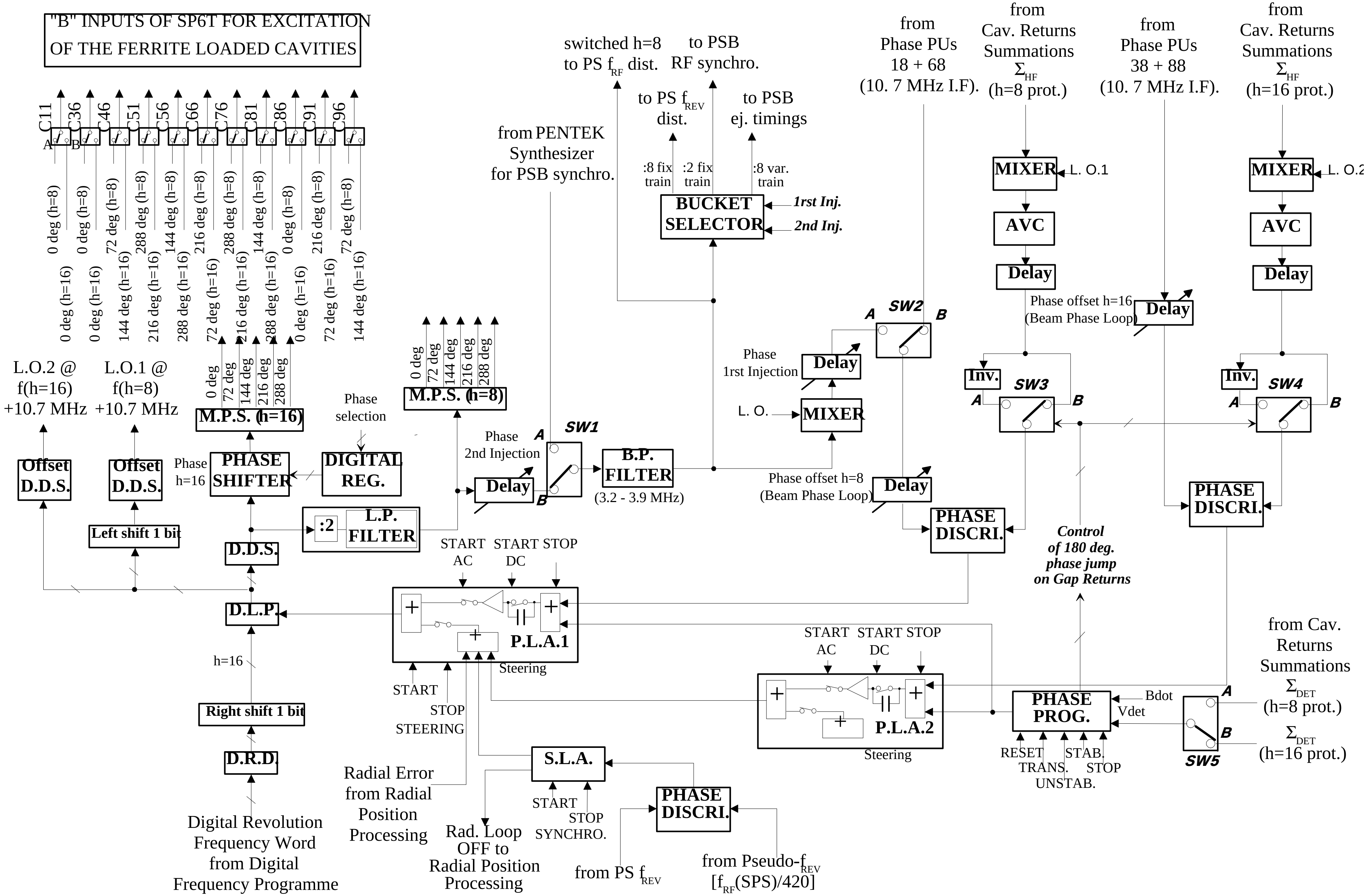


Figure 6: Beam control on h=8 + 16 for protons

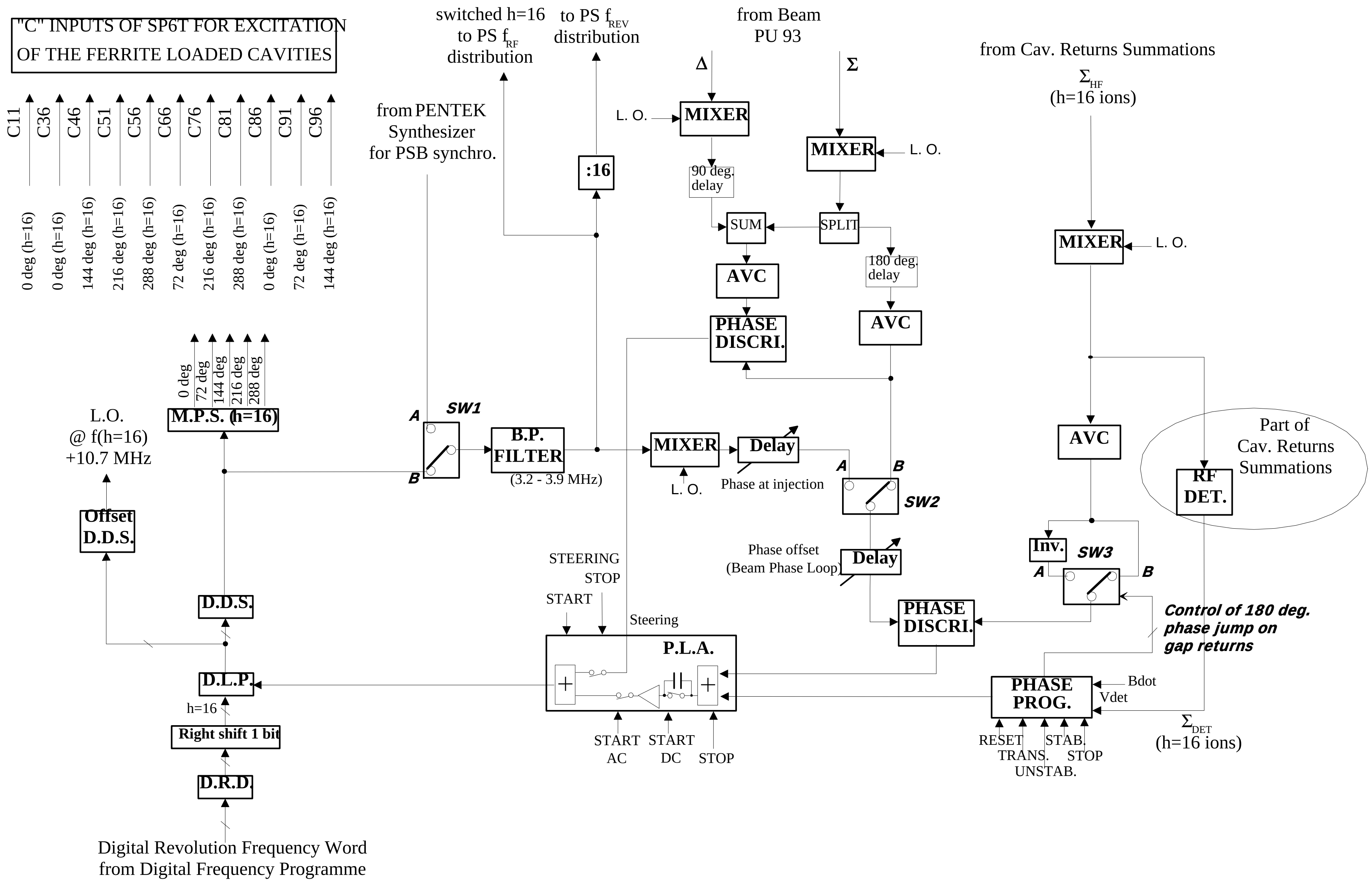


Figure 7: Beam control on h=16 for Lead ions

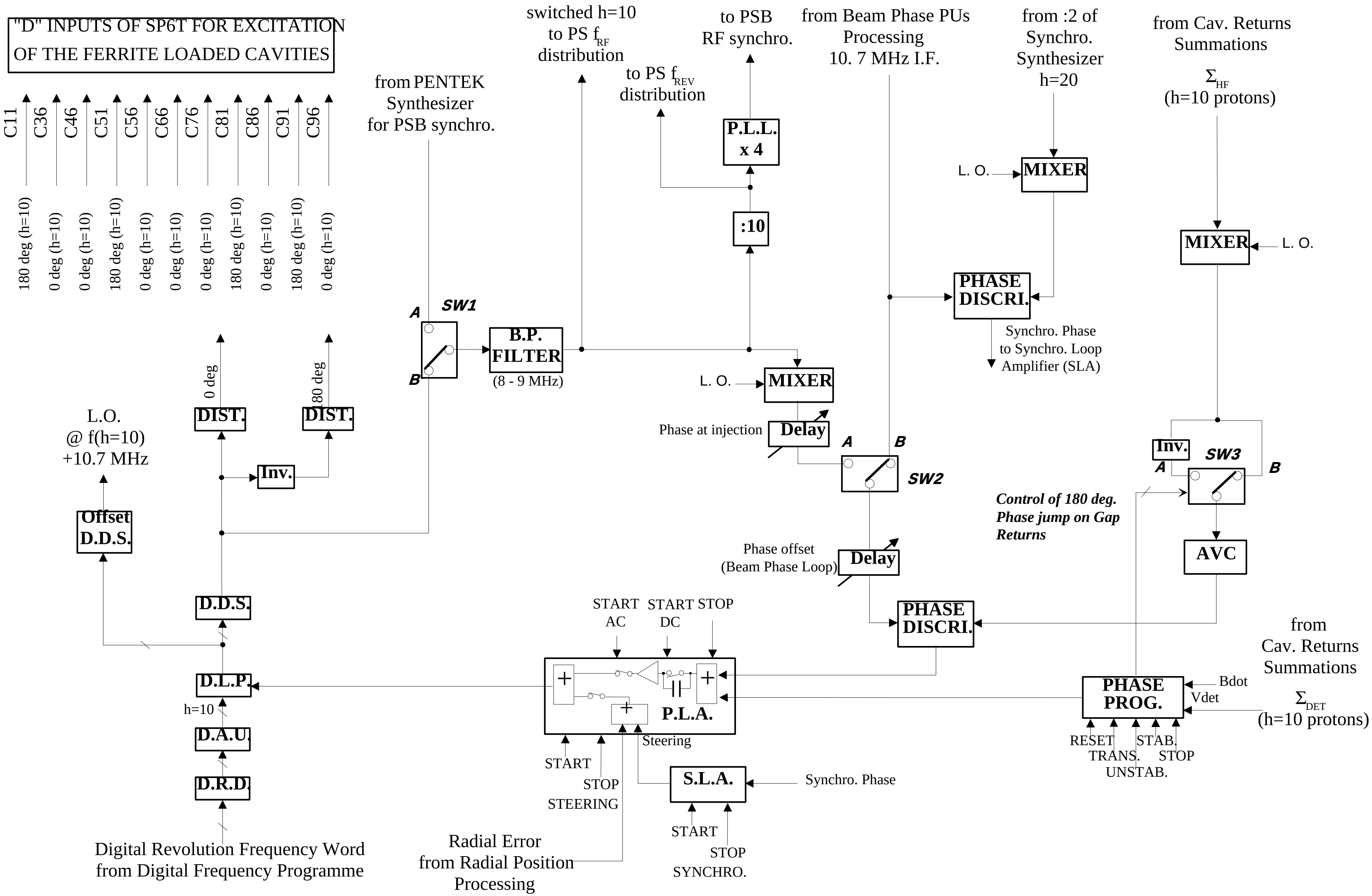
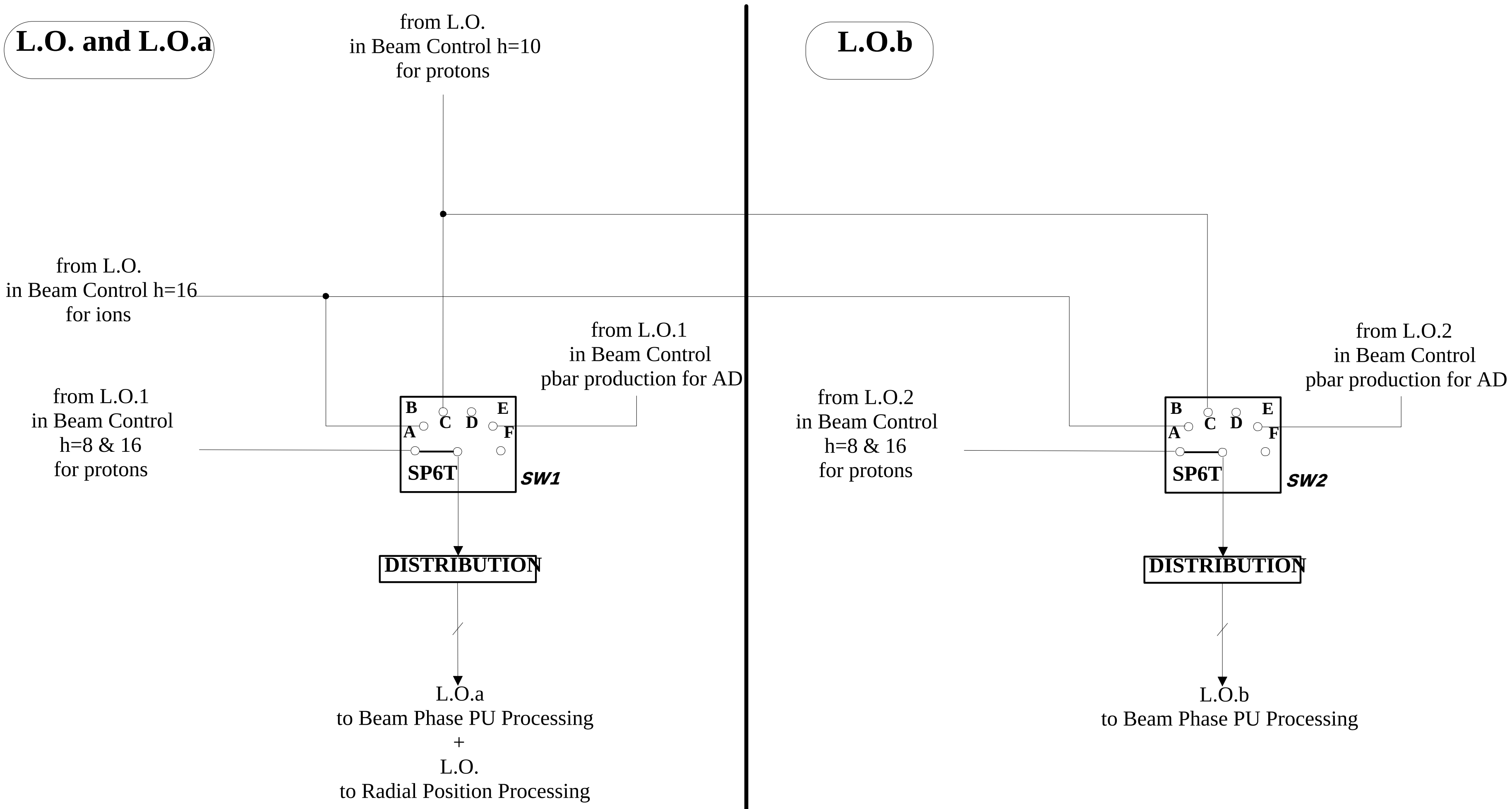


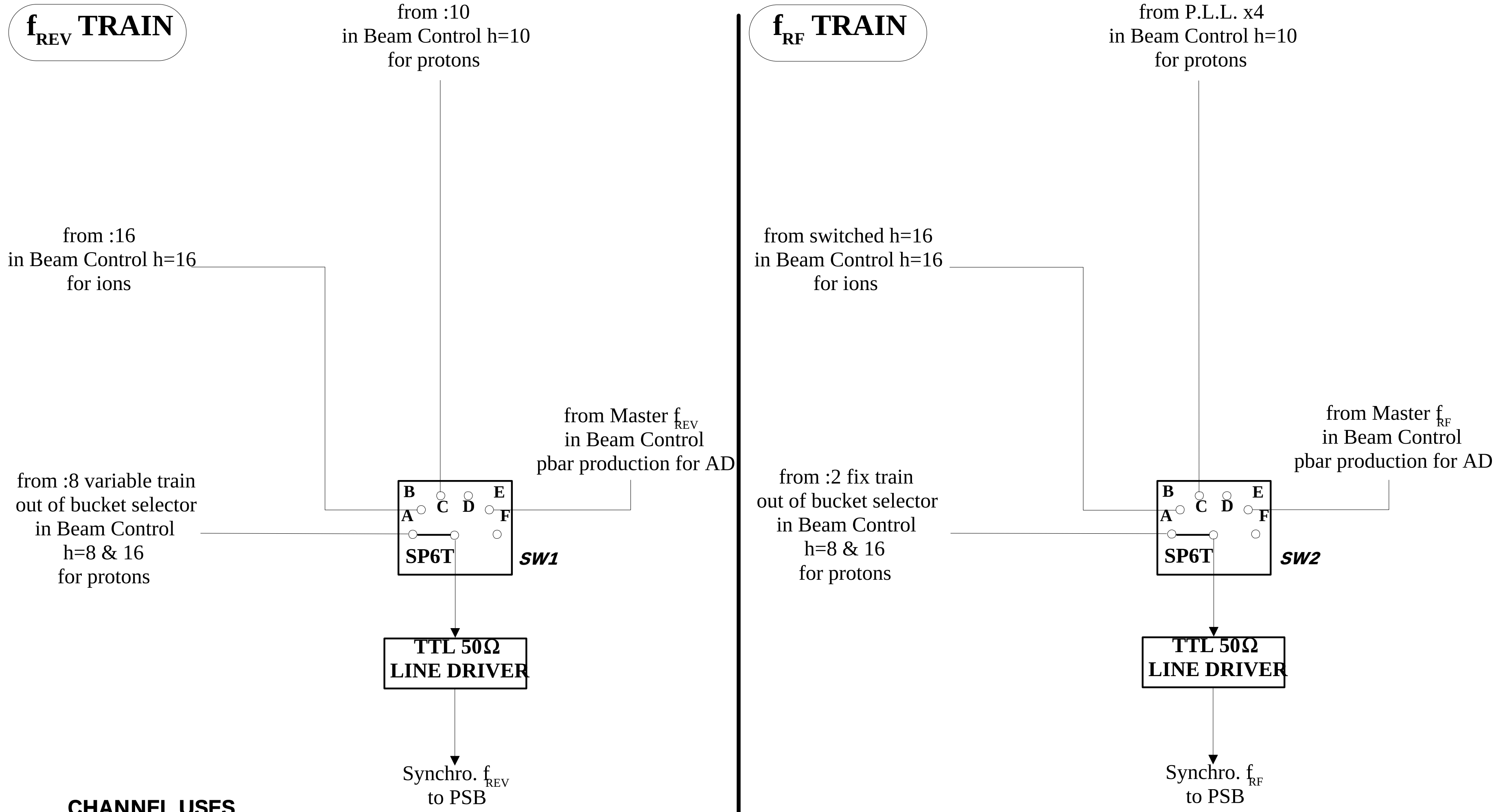
Figure 8: Beam control on h=10 for protons (temporary pbar production beam)



CHANNEL USES

A	H=8 & 16 FOR PROTONS
B	H=16 FOR IONS
C	H=10 FOR PROTONS
D	H=8 & 240 FOR LEPTONS
E	HSWP FOR AD PRODUCTION BEAM
F	

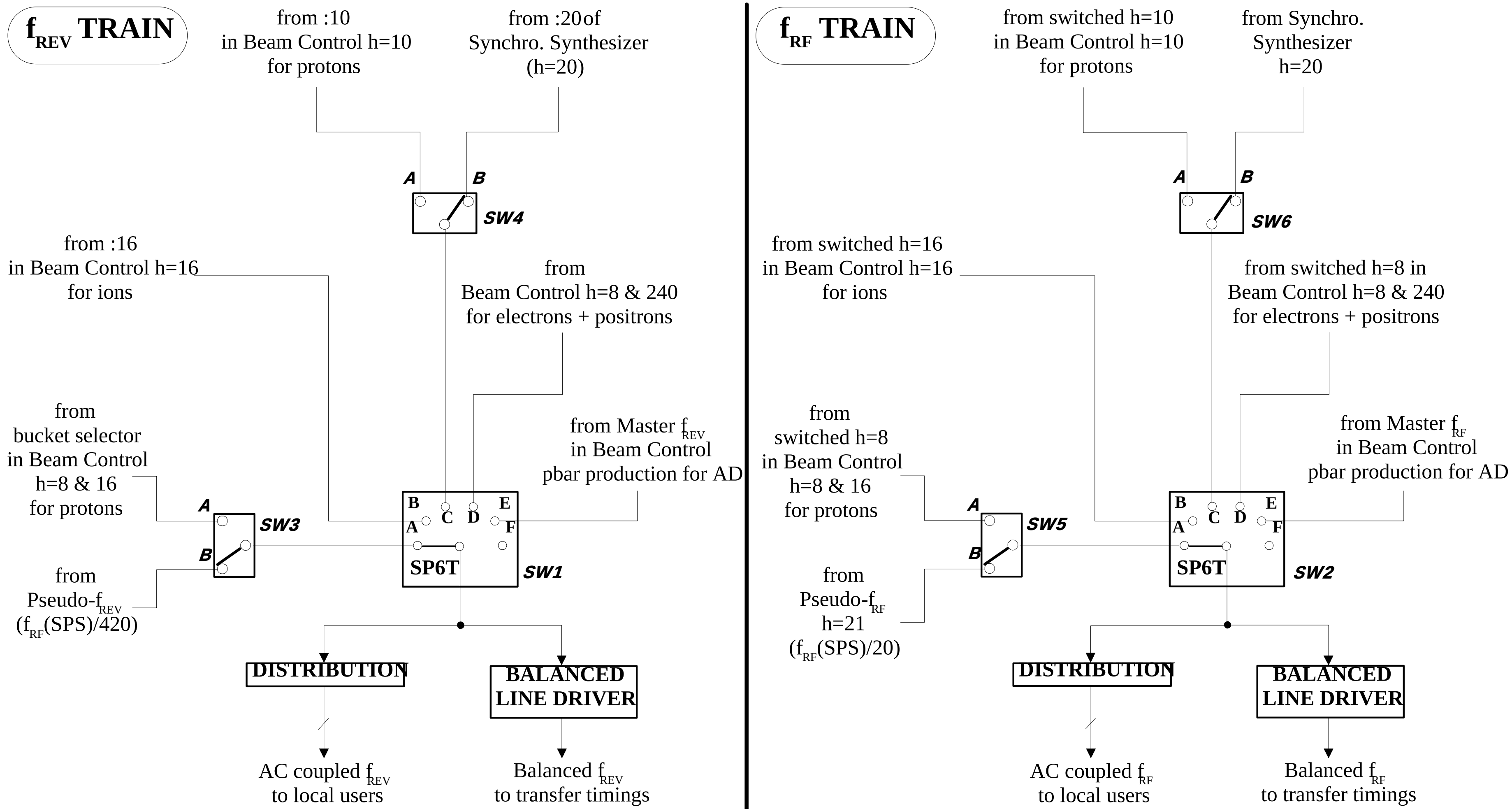
Figure 9: Selection of Local Oscillators



CHANNEL USES

A	H=8 & 16 FOR PROTONS
B	H=16 FOR IONS
C	H=10 FOR PROTONS
D	H=8 & 240 FOR LEPTONS
E	HSWP FOR AD PRODUCTION BEAM
F	

Figure 10: Selection of trains for PSB synchronization



CHANNEL USES

A	H=8 & 16 FOR PROTONS
B	H=16 FOR IONS
C	H=10 FOR PROTONS
D	H=8 & 240 FOR LEPTONS
E	HSWP FOR AD PRODUCTION BEAM
F	

Figure 11: Selection of RF and Revolution frequency trains

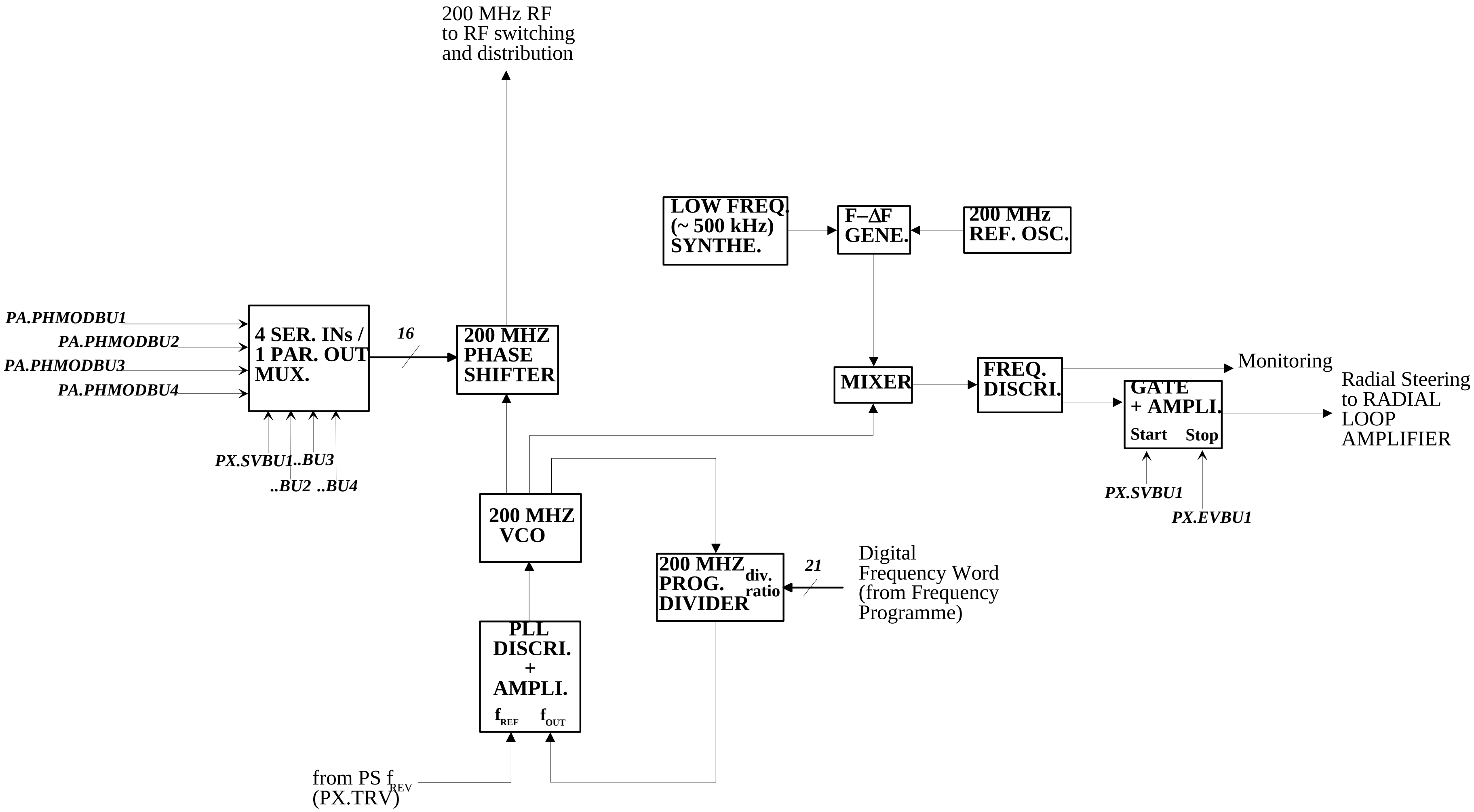


Figure 12: 200 MHz Blow-up signal generation

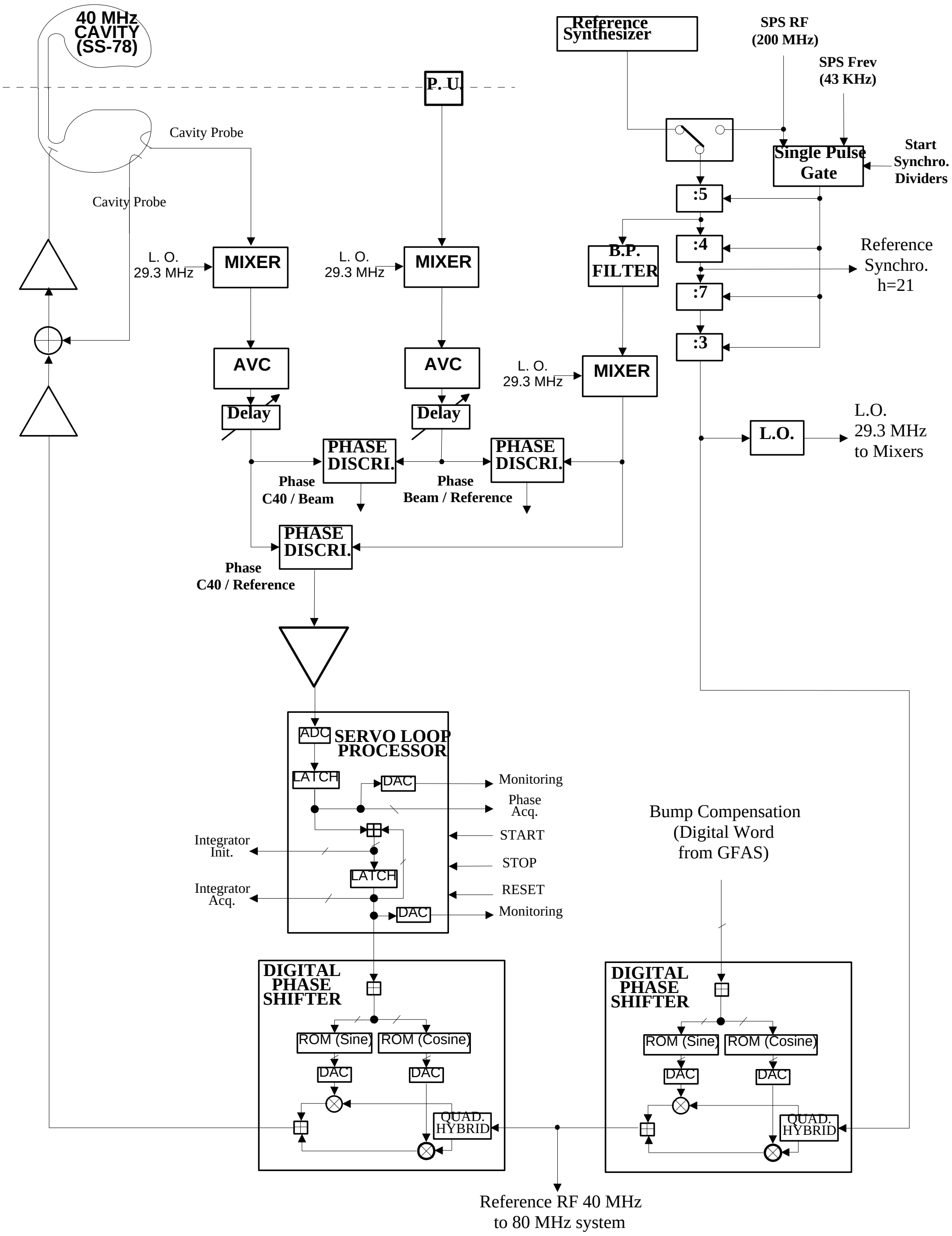


Figure 13: Low level RF on h=84 (40 MHz)

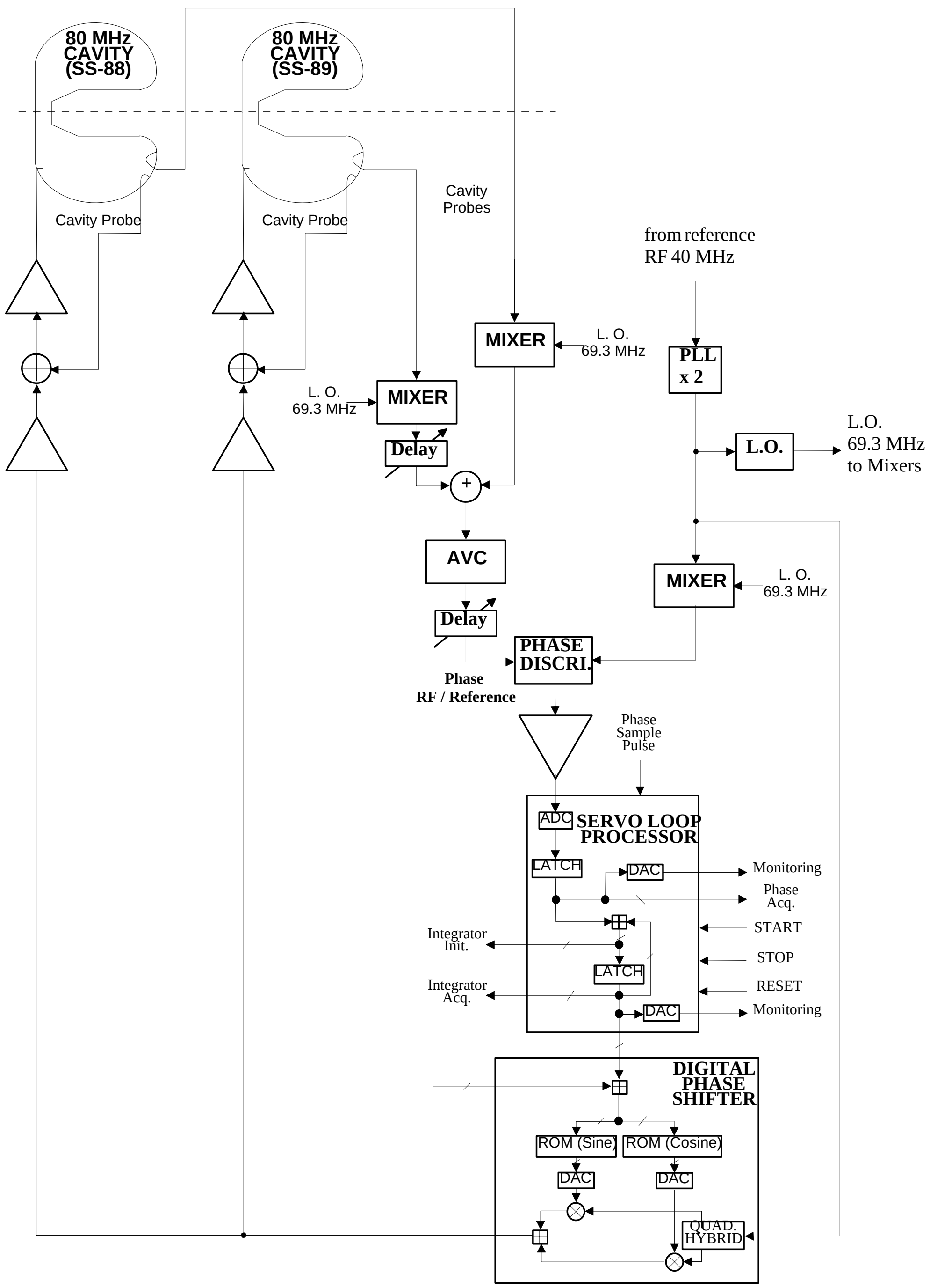


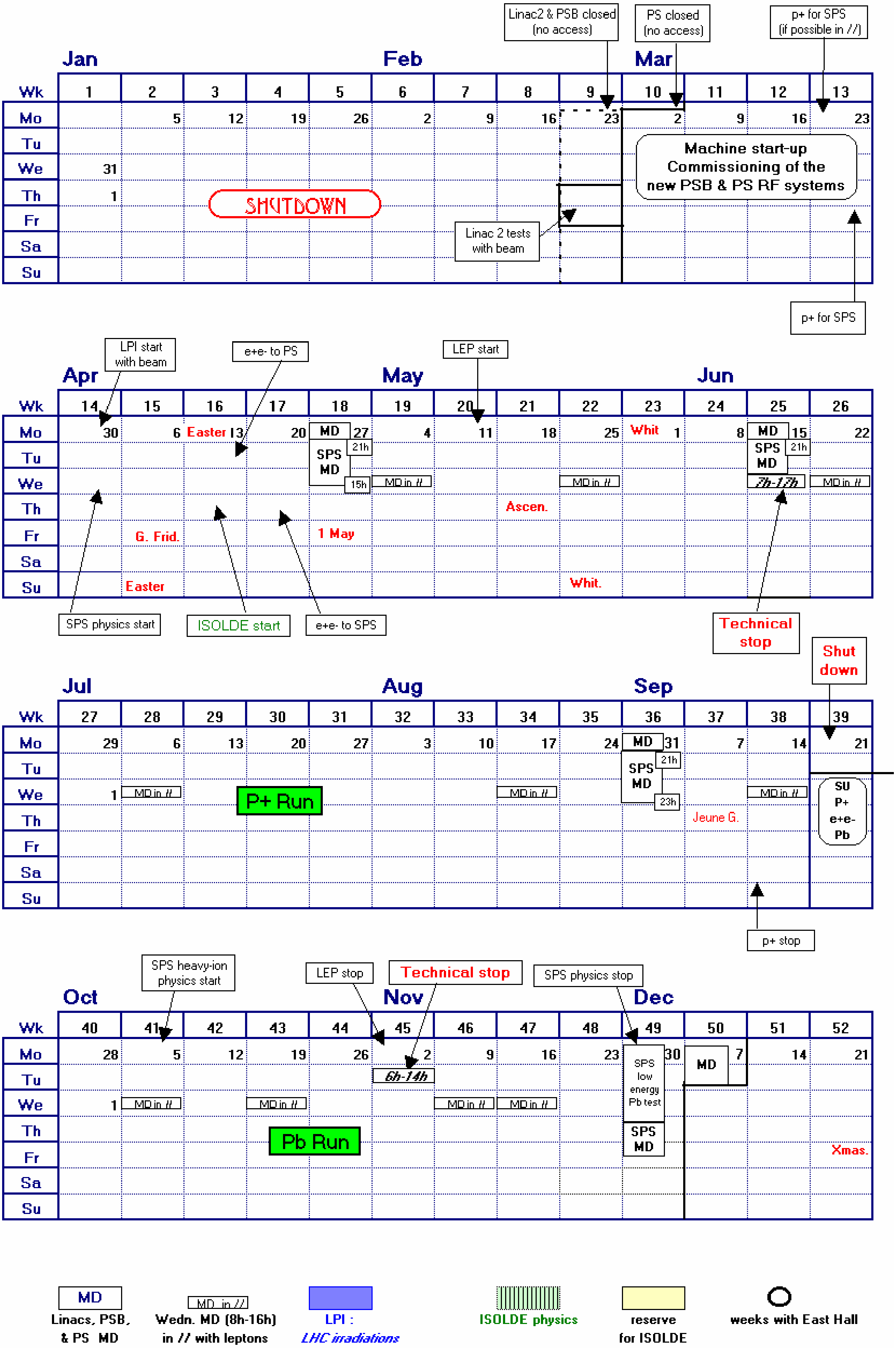
Figure 14: Low level RF on h=168 (80 MHz)

jb - 21/8/97

ANNEX 1

DRAFT

1998 - PS COMPLEX SCHEDULE



ANNEX 2: OPERATION OF THE BEAM CONTROL ON H=8 + 16 FOR PROTONS
- SEQUENCE OF EVENTS -

PS CONTROL PARAMETERS												
BEAM CONTROL H=8 & 16 FOR H+												
R. Garoby 3/10/97												
			"PS BEAM CONTROL H=8 & 16 FOR PROTONS"									
			CAVITIES SP2T				**SW1**		**SW2**		**SW5**	
TYPE	**DESCRIPTION**	**NAME**	**C36, 46 on A**	**C36 + 46 on B**	**C51 to 96 on A**	**C51 to 96 on B**	**On A**	**On B**	**On A**	**On B**	**On A**	**On B**
TIMINGS												
	Reset at End of Cycle	ELFT	x		x							
	Init at Beginning of Cycle	STC					x		x		x	
	Start h=8 + 16											
	Switch C51 to 96 on h=16					x						
	Start Ph. Loop (lock on PENTEK)											
	Lock on beam after injection							x		x		
	Lock on h=16 signal											x
	Unlock on h=8 signal											
	Switch C36 + 46 on h=16			x								
	Transition phase jump											
	Jump on unstable phase											
	Back to stable phase											
	Start Synchro. fREV											
	Stop Synchro. fREV											
	Start Debunching											
	Stop Phase Loop											

ANNEX 2 (Continued)

PS CONTROL PARAMETERS											
BEAM CONTROL H=8 & 16 FOR H+											
R. Garoby	3/10/97										
			PH. LOOP AMP. 2					**SYNC. LOOP AMP.**		**BUCKET SELECTO**	
TYPE	**DESCRIPTION**	**NAME**	**START AC**	**START DC**	**STOP**	**START Steer.**	**STOP Steer.**	**START**	**STOP**	**1rst Inject.**	**2nd Inject.**
TIMINGS											
	Reset at End of Cycle	ELFT			x		x		x	x	
	Init at Beginning of Cycle	STC									
	Start h=8 + 16										
	Switch C51 to 96 on h=16										
	Start Ph. Loop (lock on PENTEK)										
	Lock on beam after injection										x
	Lock on h=16 signal		x								
	Unlock on h=8 signal										
	Switch C36 + 46 on h=16										
	Transition phase jump										
	Jump on unstable phase										
	Back to stable phase										
	Start Synchro. fREV							x			
	Stop Synchro. fREV								x		
	Start Debunching										
	Stop Phase Loop				x						

ANNEX 2 (Continued)

			C36 + 46	C51 + 56	C66 + 76	C81 + 91	C86 + 96	SW1	SW2	SW1	SW2	SW3	SW5
TYPE	**DESCRIPTION**	**NAME**	**On B**	**On B**	**On B**	**On B**	**On B**	**On A**	**On A**	**On A**	**On A**	**On A**	**On A**
TIMINGS													
	Reset at End of Cycle	ELFT	x	x	x	x	x	x	x	x	x	x	x
	Init at Beginning of Cycle	STC											
	Start h=8 + 16		x	x	x	x	x	x	x	x	x	x	x
	Switch C51 to 96 on h=16												
	Start Ph. Loop (lock on PENTEK)												
	Lock on beam after injection												
	Lock on h=16 signal												
	Unlock on h=8 signal												
	Switch C36 + 46 on h=16												
	Transition phase jump												
	Jump on unstable phase												
	Back to stable phase												
	Start Synchro. fREV												
	Stop Synchro. fREV												
	Start Debunching												
	Stop Phase Loop												

ANNEX 2 (Continued)

PS CONTROL PARAMETERS								
BEAM CONTROL H=8 & 16 FOR H+								
R. Garoby	3/10/97							
			"BEAM PHASE PUs PROCESSING."	**"SELECTION OF LOCAL OSCILL."**		**"RADIAL POSITION PROCESSING"**		
			DIGITAL REGISTER	**SW1**	**SW2**	**RAD. LOOP AMP.**		
TYPE	**DESCRIPTION**	**NAME**	**Set H=16**	**On A**	**On A**	**G=0**	**G=-1**	**G=1**
TIMINGS								
	Reset at End of Cycle	ELFT	x	x	x	x		
	Init at Beginning of Cycle	STC					x	
	Start h=8 + 16		x	x	x			
	Switch C51 to 96 on h=16							
	Start Ph. Loop (lock on PENTEK)							
	Lock on beam after injection							
	Lock on h=16 signal							
	Unlock on h=8 signal							
	Switch C36 + 46 on h=16							
	Transition phase jump							x
	Jump on unstable phase							
	Back to stable phase							
	Start Synchro. fREV							
	Stop Synchro. fREV							
	Start Debunching							
	Stop Phase Loop					x		

ANNEX 2 (Continued)

TYPE	DESCRIPTION	NAME	Stable Phase	STOP	Trans.	Unstab. Phase	START AC	START DC	STOP	START Steer.	STOP Steer.
TIMINGS											
	Reset at End of Cycle	ELFT		x					x		x
	Init at Beginning of Cycle	STC	x								
	Start h=8 + 16										
	Switch C51 to 96 on h=16										
	Start Ph. Loop (lock on PENTEK)							x			
	Lock on beam after injection						x			x	
	Lock on h=16 signal										
	Unlock on h=8 signal								x		
	Switch C36 + 46 on h=16										
	Transition phase jump				x						
	Jump on unstable phase					x					
	Back to stable phase		x								
	Start Synchro. fREV										
	Stop Synchro. fREV										
	Start Debunching			x							
	Stop Phase Loop								x		x

ANNEX 3: OPERATION OF THE BEAM CONTROL FOR IONS ON H=16
- SEQUENCE OF EVENTS -

PS CONTROL PARAMETERS																
BEAM CONTROL H=16 FOR IONS																
R. Garoby	3/10/97															
			"PS BEAM CONTROL H=16 FOR IONS"													
			SW1		**SW2**		**PH. PROG.**				**PH. LOOP AMP.**					
TYPE	**DESCRIPTION**	**NAME**	**On A**	**On B**	**On A**	**On B**	**Stable Phase**	**STOP**	**Trans.**	**Unstab. Phase**	**START AC**	**START DC**	**STOP**	**START Steer.**	**STOP Steer.**
TIMINGS																
	Reset at End of Cycle	ELFT						X					X		X
	Init at Beginning of Cycle	STC	X		X		X								
	Start h=16 Ions														
	Switch all cavities on h=16 Ions														
	Start Ph. Loop (lock on											X			
	Lock on beam after injection			X		X					X				
	Start Radial Loop													X	
	Transition phase jump								X						
	Jump on unstable phase									X					
	Back to stable phase						X								
	Stop Radial Loop														X
	Stop Phase Loop												X		X

ANNEX 3: (Continued)

BEAM CONTROL H=16 FOR IONS														
R. Garoby 3/10/97														
			"SELECTION OF CAVITIES DRIVES (SP6T MATRIX)"					"SELECTION OF TRAINS FOR PSB SYNCHRO."		"PS REV. AND RF TRAINS SELECTION"		"BEAM PHASE PUs PROCESSING."	"SELECTION OF LOCAL OSCILL."	
			C36 + 46	**C51 + 56**	**C66 + 76**	**C81 + 91**	**C86 + 96**	**SW1**	**SW2**	**SW1**	**SW2**	**DIGITAL REGISTER**	**SW1**	**SW2**
TYPE	**DESCRIPTION**	**NAME**	**On C**	**On C**	**On C**	**On C**	**On C**	**On B**	**On B**	**On B**	**On B**	**Set H=16**	**On B**	**On B**
TIMINGS														
	Reset at End of Cycle	ELFT										x		
	Init at Beginning of Cycle	STC												
	Start h=16 Ions									x	x	x	x	x
	Switch all cavities on h=16 Ions		x	x	x	x	x	x	x					
	Start Ph. Loop (lock on PENTEK)													
	Lock on beam after injection													
	Start Radial Loop													
	Transition phase jump													
	Jump on unstable phase													
	Back to stable phase													
	Stop Radial Loop													
	Stop Phase Loop													

ANNEX 4: OPERATION OF THE BEAM CONTROL FOR PBAR PRODUCTION ON H=10
- SEQUENCE OF EVENTS -

PS CONTROL PARAMETERS															
BEAM CONTROL H=10 FOR H+															
R. Garoby 3/10/97															
			"PS BEAM CONTROL H=10 FOR H+												
			SW1		**SW2**		**PH. PROG.**				**PH. LOOP AMP.**				
TYPE	**DESCRIPTION**	**NAME**	**On A**	**On B**	**On A**	**On B**	**Stable Phase**	**STOP**	**Trans.**	**Unstab. Phase**	**START AC**	**START DC**	**STOP**	**START Steer.**	**STOP Steer.**
TIMINGS															
	Reset at End of Cycle	ELFT						x					x		x
	Init at Beginning of Cycle	STC	x		x		x								
	Start h=10														
	Switch all cavities on h=10														
	Start Ph. Loop (lock on PENTEK)											x			
	Lock on beam after injection			x		x					x				
	Transition phase jump								x						
	Start Synchro. fREV							x							
	Switch distrib. on pseudo-trains														
	Stop Synchro. fREV														
	Jump on unstable phase									x					
	Back to stable phase						x								
	Stop Phase Loop												x		x

ANNEX 4: (Continued)

PS CONTROL PARAMETERS											
BEAM CONTROL H=10 FOR H+											
R. Garoby 3/10/97											
					"SELECTION OF CAVITIES DRIVES (SP6T MATRIX)"					**"SELECTION OF TRAINS FOR PSB SYNCHRO."**	
			SYNC. LOOP AMP.		**C36 + 46**	**C51 + 56**	**C66 + 76**	**C81 + 91**	**C86 + 96**	**SW1**	**SW2**
TYPE	**DESCRIPTION**	**NAME**	**START**	**STOP**	**On D**	**On D**	**On D**	**On D**	**On D**	**On C**	**On C**
TIMINGS											
	Reset at End of Cycle	ELFT		x							
	Init at Beginning of Cycle	STC									
	Start h=10									x	x
	Switch all cavities on h=10				x	x	x	x	x		
	Start Ph. Loop (lock on PENTEK)										
	Lock on beam after injection										
	Transition phase jump										
	Start Synchro. fREV		x								
	Switch distrib. on pseudo-trains										
	Stop Synchro. fREV			x							
	Jump on unstable phase										
	Back to stable phase										
	Stop Phase Loop										

ANNEX 4: (Continued)

PS CONTROL PARAMETERS														
BEAM CONTROL H=10 FOR H+														
R. Garoby	3/10/97													
			"PS REV. AND RF TRAINS SELECTION"						**"BEAM PHASE PUs PROCESSING."**	**"SELECTION OF LOCAL OSCILL."**		**"RADIAL POSITION PROCESSING"**		
			SW1	**SW2**	**SW4**		**SW6**		**DIGITAL REGISTER**	**SW1**	**SW2**	**RAD. LOOP AMP.**		
TYPE	**DESCRIPTION**	**NAME**	**On C**	**On C**	**On A**	**On B**	**On A**	**On B**	**Set H=10**	**On C**	**On C**	**G=0**	**G=-1**	**G=1**
TIMINGS														
	Reset at End of Cycle	ELFT			x		x					x		
	Init at Beginning of Cycle	STC											x	
	Start h=10		x	x					x	x	x			
	Switch all cavities on h=10													
	Start Ph. Loop (lock on PENTEK)													
	Lock on beam after injection													
	Transition phase jump													x
	Start Synchro. fREV													
	Switch distrib. on pseudo-trains					x		x						
	Stop Synchro. fREV													
	Jump on unstable phase													
	Back to stable phase													
	Stop Phase Loop													

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